

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

**Patent Application**

5 Applicant(s): Khalil C Haddad  
Case: 1  
Serial No.: 09/803,801  
Filing Date: March 12, 2001  
Group: 2611  
10 Examiner: Jason M. Perilla  
  
Title: Shortening Impulse Response Filter (SIRF) and Design Technique Therefor

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TWICE CORRECTED APPEAL BRIEF

Mail Stop Appeal Brief – Patents  
Commissioner for Patents  
20 P.O. Box 1450  
Alexandria, VA 22313-1450

25 Sir:

Appellants hereby submit this corrected Appeal Brief to conform to the current format requirements. The original Appeal Brief was submitted on February 15, 2007 to appeal the non-final rejection of claims 1-8, 10-16, 18-26, and 28 in the Office Action, mailed November 16, 2006.

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REAL PARTY IN INTEREST

The present application is assigned to Agere Systems Inc., as evidenced by a statement under 37 CFR 3.73 (b) submitted on April 16, 2006, and an assignment recorded on March 12, 2001 in the United States Patent and Trademark Office at Reel 011638, Frame 0828.

35 The assignee, Agere Systems Inc., is the real party in interest.

RELATED APPEALS AND INTERFERENCES

There are no related appeals or interferences that will directly affect or be directly affected by or have a bearing on the decision in the present appeal.

### STATUS OF CLAIMS

The present application was filed on March 12, 2001 with claims 1 through 28. Claims 9, 17, and 27 were cancelled in the Amendment and Response to Office Action dated September 17, 2004. Claims 1-8, 10-16, 18-26, and 28 are presently pending in the above-identified patent application. Claims 1, 2, 4-6, 10-12, 14-16, and 18 are rejected under 35 U.S.C. §103(a) as being unpatentable over Nedic et al. (United States Patent Number 6,563,841; hereinafter "Nedic") in view of Haddad et al. ("Design of Digital Linear-Phase FIR Crossover Systems of Loudspeakers by the Method of Vector Space Projections," Haddad, Khalil C et al; hereinafter "Haddad"), claims 19, 20, 22-24, and 28 are rejected under 35 U.S.C. §103(a) as being unpatentable over Nedic in view of Haddad, and in further view of Gandhi et al. (United States Patent Number 6,112,218; hereinafter "Gandhi"), and claims 3, 7, 8, 13, 21, 25, and 26 are rejected under 35 U.S.C. §103(a) as being unpatentable over Nedic in view of Haddad, and further in view of Khalil C ("Constrained FIR Filter Design by the Method of Vector Space Projections," Haddad, Khalil C et al; hereinafter "Khalil").

Claims 1, 2, 4-6, 10-12, 14-16, and 18 are also rejected under 35 U.S.C. §103(a) as being unpatentable over Haddad et al. in view of Younce et al. (United States Patent Number 5,521,908), claims 19, 20, 22-24, and 28 are rejected under 35 U.S.C. §103(a) as being unpatentable over Haddad in view of Younce, and in further view of Gandhi et al., and claims 3, 7, 8, 13, 21, 25, and 26 are rejected under 35 U.S.C. §103(a) as being unpatentable over Haddad in view of Younce, and further in view of Khalil.

Claims 1, 7, 8, 10, 11, 18, 19, 25, 26, and 28 are being appealed.

### STATUS OF AMENDMENTS

There have been no amendments filed subsequent to the non-final rejection.

### SUMMARY OF CLAIMED SUBJECT MATTER

The present invention is directed to shortening impulse response filters (SIRF; FIG. 1: 120) that satisfy constraints in both the time and frequency domains (page 3, line 23, to page 4, line 25). In addition, methods and apparatus are disclosed for determining the coefficient values for SIRF filters (FIG. 1: 120; page 6, line 15, to page 7, line 13). The disclosed SIRF

filters (FIG. 1: 120) shorten the channel impulse response in the time domain while also providing a frequency response that does not attenuate or amplify the received signal (page 2, lines 20-25). One or more sets define constraints that the SIRF filter (FIG. 1: 120) must satisfy in the time domain, and one or more sets define constraints that the SIRF filter (FIG. 1: 120) must satisfy in the frequency domain. By varying the sets utilized to define the time and frequency domain constraints, SIRF filters (FIG. 1: 120) having a linear or non-linear phase response may be obtained. The intersection of the various sets defines the coefficients for the SIRF filters (FIG. 1: 120). Vector space projection methods are utilized to determine the intersection set (page 7, line 14, to page 8, line 7).

Independent claim 1 is directed to a method (FIG. 3: 300) for determining coefficient values for a shortening impulse response filter (SIRF) (FIG. 1: 120; page 3, line 23, to page 4, line 25), comprising the steps of: establishing at least one set of defining constraints that the SIRF filter (FIG. 1: 120) must satisfy in a time domain (page 7, lines 1-13); establishing at least one set of defining constraints that the SIRF filter (FIG. 1: 120) must satisfy in a frequency domain (page 7, lines 1-13); and determining an intersecting set of at least one set of the defining constraints that the SIRF filter (FIG. 1: 120) must satisfy in the time domain and at least one set of defining constraints that the SIRF filter (FIG. 1: 120) must satisfy in the frequency domain by employing vector space projection methods (page 7, lines 1-13).

Independent claim 11 is directed to a shortening impulse response filter (SIRF) (FIG. 1: 120), comprising: a set of finite impulse response (FIR) coefficients satisfying at least one constraint in a time domain and at least one constraint in a frequency domain (page 7, lines 1-13), wherein the at least one time domain constraint is represented as at least one first set and wherein the at least one frequency domain constraint is represented as at least one second set, wherein the finite impulse response (FIR) coefficients are determined by an intersecting set of the at least one first set defining the time domain constraints and the at least one second set defining the frequency domain constraints, wherein the intersecting set is determined by employing vector space projection methods (page 7, line 14, to page 8, line 7).

Independent claim 19 is directed to a system for determining coefficient values for a shortening impulse response filter (SIRF) (FIG. 1: 120), the system comprising: a memory that stores computer-readable code; and a processor operatively coupled to the memory, the

processor configured to implement the computer-readable code, the computer-readable code configured to: establish at least one set of defining constraints that the SIRF filter (FIG. 1: 120) must satisfy in a time domain (page 7, lines 1-13); establish at least one set of defining constraints that the SIRF filter (FIG. 1: 120) must satisfy in a frequency domain (page 7, lines 1-13); and determine an intersecting set of the at least one set of defining constraints that the SIRF filter (FIG. 1: 120) must satisfy in the time domain and the at least one set of defining constraints that the SIRF filter (FIG. 1: 120) must satisfy in the frequency domain by employing vector space projection methods (page 7, lines 1-13)

In one exemplary embodiment, the at least one set of defining constraints that the SIRF filter (FIG. 1: 120) must satisfy in the frequency domain is defined as follows:

$$C_2 \equiv \left\{ \mathbf{h} \in R^N : 1 - \alpha \leq |H(\omega)| \leq 1 + \alpha \text{ for } \omega \in \Omega_p \right. \\ \left. \text{and } |H(\omega)| \leq \beta \text{ for } \omega \in \Omega_s \right\}.$$

where  $\mathbf{h}$  is the impulse response of length  $N$  of the SIRF filter (FIG. 1: 120) that shortens the impulse response of a channel,  $\omega$  is a frequency,  $\alpha$  and  $\beta$  are error tolerance regions of frequency and time domain, respectively,  $H(\omega)$  is the impulse response in the frequency domain,  $R^N$  is the Hilbert space of dimension  $N$ ,  $\Omega_p$  is the pass-band and  $\Omega_s$  is the stop-band (page 5, line 6, to page 6, line 5)

In one exemplary embodiment, the at least one set of defining constraints that the SIRF filter (FIG. 1: 120) must satisfy in the frequency domain is defined as follows:

$$C_3 \equiv \left\{ \mathbf{h} \in R^N : 1 - \alpha \leq A(\omega) \leq 1 + \alpha \right. \\ \left. \text{and } \Phi(\omega) = -\omega(N-1)/2 \text{ for } \omega \in \Omega_p \right. \\ \left. |H(\omega)| \leq \beta \text{ for } \omega \in \Omega_s \right\}.$$

where  $\mathbf{h}$  is the impulse response of length  $N$  of the SIRF filter (FIG. 1: 120) that shortens the impulse response of a channel,  $\omega$  is a frequency,  $\alpha$  and  $\beta$  are error tolerance regions of frequency and time domain, respectively,  $H(\omega)$  is the impulse response in the frequency domain,  $R^N$  is the Hilbert space of dimension  $N$ ,  $\Omega_p$  is the pass-band,  $\Omega_s$  is the stop-band,

$$A(\omega) = \sum_0^{N/2-1} 2h(n) \cos \left[ \left( n - \frac{N-1}{2} \right) \omega \right] \text{ and } \Phi(\omega) = -\frac{N-1}{2} \omega, \text{ wherein } \Phi(\omega) \text{ and } A(\omega) \text{ are}$$

independent filter characteristics and wherein  $\Phi(\omega)$  is a linear phase and  $A(\omega)$  is an amplitude  
(page 5, line 6, to page 6, line 5)

STATEMENT OF GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

Claims 1, 2, 4-6, 10-12, 14-16, and 18 are rejected under 35 U.S.C. §103(a) as being unpatentable over Nedic et al. in view of Haddad et al., claims 19, 20, 22-24, and 28 are rejected under 35 U.S.C. §103(a) as being unpatentable over Nedic in view of Haddad, and in further view of Gandhi et al., and claims 3, 7, 8, 13, 21, 25, and 26 are rejected under 35 U.S.C. §103(a) as being unpatentable over Nedic in view of Haddad, and further in view of Khalil

Claims 1, 2, 4-6, 10-12, 14-16, and 18 are rejected under 35 U.S.C. §103(a) as being unpatentable over Haddad et al. in view of Younce et al., claims 19, 20, 22-24, and 28 are rejected under 35 U.S.C. §103(a) as being unpatentable over Haddad in view of Younce, and in further view of Gandhi et al., and claims 3, 7, 8, 13, 21, 25, and 26 are rejected under 35 U.S.C. §103(a) as being unpatentable over Haddad in view of Younce, and further in view of Khalil

## ARGUMENT

### Independent Claims 1 and 11: First Rejection

Independent claims 1 and 11 are rejected under 35 U.S.C. §103(a) as being unpatentable over Nedic in view of Haddad. Regarding claim 1, the Examiner acknowledges that Nedic does not explicitly disclose a method of determining the values of the coefficients via vector space projection methods (VSPM), but asserts that Haddad teaches a method to solve a mathematical problem encompassing multiple constraints by vector space projection. The Examiner further asserts that, because a SIRF filter is a particular type of FIR filter, one skilled in the art would be motivated to use Haddad's exemplary coefficient determining method for SIRF filters as well as FIR filters.

Appellant notes that the concept of sets, intersection of sets and projections, and the modeling of constraints with mathematical sets are *not* disclosed or suggested by Nedic. In SIRF filter design, constraints in the time domain are needed in general to prevent spectral nulls from showing up in the solution of the coefficients. Nedic does not disclose or suggest *determining an intersecting set of at least one set of defining constraints that a SIRF filter must*

*satisfy in the time domain and at least one set of defining constraints that the SIRF filter must satisfy in the frequency domain by employing vector space projection methods*

Appellant could also find no disclosure or suggestion in any of the cited references to combine the SIRF design disclosed by Nedic with the method disclosed by Haddad.

5 Independent claims 1 and 11 require establishing at least one set of defining constraints that said SIRF filter must satisfy in a time domain; establishing at least one set of defining constraints that said SIRF filter must satisfy in a frequency domain; and determining an intersecting set of said at least one set of defining constraints that said SIRF filter must satisfy in the time domain and said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain  
10 by employing vector space projection methods.

Thus, Nedic, Younce, Haddad, and Gandhi, alone or in any combination, do not disclose or suggest establishing at least one set of defining constraints that said SIRF filter must satisfy in a time domain; establishing at least one set of defining constraints that said SIRF filter must satisfy in a frequency domain; and determining an intersecting set of said at least one set of  
15 defining constraints that said SIRF filter must satisfy in the time domain and said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain by employing vector space projection methods, as required by independent claims 1 and 11

Independent Claim 1 and 11: Second Rejection

Independent claims 1 and 11 are also rejected under 35 U.S.C. §103(a) as being  
20 unpatentable over Haddad et al. in view of Younce et al. Regarding claim 1, the Examiner asserts that Younce teaches that an SIRF filter is a type of FIR filter and that, because the VSPM method of Haddad allows for significant flexibility in that any number of constraints may be incorporated into the design, one skilled in the art would find it advantageous to use the method to design not only FIR filters but similar filters such as SIRF filters as suggested by Younce  
25 depending upon the type and response of filter required.

Appellant notes that the concept of sets, intersection of sets and projections, and the modeling of constraints with mathematical sets are *not* disclosed or suggested by Younce. In SIRF filter design, constraints in the time domain are needed in general to prevent spectral nulls from showing up in the solution of the coefficients. Younce, for example, solves linear  
30 equations in the time domain to find the coefficients. Younce does not disclose or suggest

*determining an intersecting set of at least one set of defining constraints that a SIRF filter must satisfy in the time domain and at least one set of defining constraints that the SIRF filter must satisfy in the frequency domain by employing vector space projection methods.*

Appellant could also find no disclosure or suggestion in any of the cited references to combine the SIRF design disclosed by Younce with the method disclosed by Haddad. Independent claims 1 and 11 require establishing at least one set of defining constraints that said SIRF filter must satisfy in a time domain; establishing at least one set of defining constraints that said SIRF filter must satisfy in a frequency domain; and determining an intersecting set of said at least one set of defining constraints that said SIRF filter must satisfy in the time domain and said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain by employing vector space projection methods.

Thus, Nedic, Younce, Haddad, and Gandhi, alone or in any combination, do not disclose or suggest establishing at least one set of defining constraints that said SIRF filter must satisfy in a time domain; establishing at least one set of defining constraints that said SIRF filter must satisfy in a frequency domain; and determining an intersecting set of said at least one set of defining constraints that said SIRF filter must satisfy in the time domain and said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain by employing vector space projection methods, as required by independent claims 1 and 11.

Independent Claim 19: First Rejection

Independent claim 19 is rejected under 35 U.S.C. §103(a) as being unpatentable over Nedic in view of Haddad, and in further view of Gandhi et al. As noted in rejecting claim 1, the Examiner acknowledges that Nedic does not explicitly disclose a method of determining the values of the coefficients via vector space projection methods (VSPM), but asserts that Haddad teaches a method to solve a mathematical problem encompassing multiple constraints by vector space projection. The Examiner further asserts that, because a SIRF filter is a particular type of FIR filter, one skilled in the art would be motivated to use Haddad's exemplary coefficient determining method for SIRF filters as well as FIR filters.

Appellant notes that the concept of sets, intersection of sets and projections, and the modeling of constraints with mathematical sets are *not* disclosed or suggested by Nedic. In SIRF filter design, constraints in the time domain are needed in general to prevent spectral nulls

from showing up in the solution of the coefficients. Nedic does not disclose or suggest *determining an intersecting set of at least one set of defining constraints that a SIRF filter must satisfy in the time domain and at least one set of defining constraints that the SIRF filter must satisfy in the frequency domain by employing vector space projection methods.*

5 Appellant could also find no disclosure or suggestion in any of the cited references to combine the SIRF design disclosed by Nedic with the method disclosed by Haddad. Independent claim 19 requires establishing at least one set of defining constraints that said SIRF filter must satisfy in a time domain; establishing at least one set of defining constraints that said SIRF filter must satisfy in a frequency domain; and determining an intersecting set of said at  
10 least one set of defining constraints that said SIRF filter must satisfy in the time domain and said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain by employing vector space projection methods.

Thus, Nedic, Younce, Haddad, and Gandhi, alone or in any combination, do not disclose or suggest establishing at least one set of defining constraints that said SIRF filter must  
15 satisfy in a time domain; establishing at least one set of defining constraints that said SIRF filter must satisfy in a frequency domain; and determining an intersecting set of said at least one set of defining constraints that said SIRF filter must satisfy in the time domain and said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain by employing vector space projection methods, as required by independent claim 19.

20 Independent Claim 19: Second Rejection

Independent claim 19 is rejected under 35 U.S.C. §103(a) as being unpatentable over Haddad in view of Younce, and in further view of Gandhi. As noted in rejecting claim 1, the Examiner asserts that Younce teaches that an SIRF filter is a type of FIR filter and that, because the VSPM method of Haddad allows for significant flexibility in that any number of  
25 constraints may be incorporated into the design, one skilled in the art would find it advantageous to use the method to design not only FIR filters but similar filters such as SIRF filters as suggested by Younce depending upon the type and response of filter required.

Appellant notes that the concept of sets, intersection of sets and projections, and the modeling of constraints with mathematical sets are *not* disclosed or suggested by Younce. In  
30 SIRF filter design, constraints in the time domain are needed in general to prevent spectral nulls



from showing up in the solution of the coefficients. Younce, for example, solves linear equations in the time domain to find the coefficients. Younce does not disclose or suggest *determining an intersecting set of at least one set of defining constraints that a SIRF filter must satisfy in the time domain and at least one set of defining constraints that the SIRF filter must*  
5 *satisfy in the frequency domain by employing vector space projection methods.*

Appellant could also find no disclosure or suggestion in any of the cited references to combine the SIRF design disclosed by Younce with the method disclosed by Haddad. Independent claim 19 requires establishing at least one set of defining constraints that said SIRF filter must satisfy in a time domain; establishing at least one set of defining constraints  
10 that said SIRF filter must satisfy in a frequency domain; and determining an intersecting set of said at least one set of defining constraints that said SIRF filter must satisfy in the time domain and said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain by employing vector space projection methods.

Thus, Nedic, Younce, Haddad, and Gandhi, alone or in any combination, do not  
15 disclose or suggest establishing at least one set of defining constraints that said SIRF filter must satisfy in a time domain; establishing at least one set of defining constraints that said SIRF filter must satisfy in a frequency domain; and determining an intersecting set of said at least one set of defining constraints that said SIRF filter must satisfy in the time domain and said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain by employing  
20 vector space projection methods, as required by independent claim 19.

#### Additional Cited References

Khalil was also cited by the Examiner for its disclosure of a VSPM method wherein a filter is designed having an arbitrary magnitude and phase response.

Appellant notes that Khalil was published in August, 2000, and therefore does not  
25 constitute prior art under 35 U.S.C. §103(a) since the present application has a filing date of March 12, 2001 (Khalil is incorporated by reference in the present specification). In any case, Khalil is directed to *FIR* filter design and does *not* address the design of *SIRF* filters. In addition, the present specification teaches that,

traditionally, VSPM techniques have been employed to design  
30 *constrained FIR filters* that are tailored to specific applications. See, K. C. Haddad, "Constrained FIR Filter Design by the Method of Vector Space

Projections,” IEEE Trans. on Circuit and Systems II: Analog and Digital Signal Processing, Vol. 47, No. 8 (Aug. 2000), incorporated by reference herein. In the context of the present invention, where VSPM techniques are employed to design an *SIRF* filter, *two (or more) convex sets representing the constraints in time and frequency domains and corresponding projection operators have been mathematically formulated*. A first convex set defines the constraints that the SIRF filter 120 must satisfy in the time domain, such that when the filter is convolved with the impulse response, the impulse response is shortened. Likewise, a second convex set defines the constraints that the SIRF filter 120 must satisfy in the frequency domain, such as a low, high or band pass band.  $P_i$  is defined to be the projection operator onto the set  $C_i$ . Thus, to obtain an SIRF filter satisfying both frequency and time constraints, an intersection of both sets is required.

(Page 4, lines 13-25; emphasis added.)

Khalil does not disclose or suggest *two (or more) convex sets representing the constraints in time and frequency domains for SIRF filter design*.

Thus, Khalil does not disclose or suggest establishing at least one set of defining constraints that said SIRF filter must satisfy in a time domain; establishing at least one set of defining constraints that said SIRF filter must satisfy in a frequency domain; and determining an intersecting set of said at least one set of defining constraints that said SIRF filter must satisfy in the time domain and said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain by employing vector space projection methods, as required by independent claims 1, 11, and 19.

#### Claims 7 and 25: First Rejection

Claims 7 and 25 are rejected under 35 U.S.C. §103(a) as being unpatentable over Nedic in view of Haddad, and further in view of Kahlil. Regarding claim 7, the Examiner asserts that Khalil discloses the additional limitations of claim 7 (page 716, col. 1, lines 20-40; col. 2).

Appellants could find no disclosure or suggestion by Khalil that a set of defining constraints that the *SIRF* filter must satisfy in the frequency domain is defined as follows:

$$C_2 \equiv \left\{ \mathbf{h} \in R^N : 1 - \alpha \leq |H(\omega)| \leq 1 + \alpha \text{ for } \omega \in \Omega_p, \right. \\ \left. \text{and } |H(\omega)| \leq \beta \text{ for } \omega \in \Omega_s, \right\}$$

where  $\mathbf{h}$  is the impulse response of length  $N$  of the SIRF filter that shortens the impulse response of a channel,  $\omega$  is a frequency,  $\alpha$  and  $\beta$  are error tolerance regions of frequency and time domain, respectively,  $H(\omega)$  is the impulse response in the frequency domain,  $R^N$  is the Hilbert space of

dimension  $N$ ,  $\Omega_p$  is the pass-band and  $\Omega_s$  is the stop-band

Thus, Nedic, Kapoor, Gandhi, Haddad, and Khalil, alone or in any combination, do not disclose or suggest wherein said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain is defined as follows:

$$C_2 \equiv \left\{ \begin{array}{l} \mathbf{h} \in R^N : 1 - \alpha \leq |H(\omega)| \leq 1 + \alpha \text{ for } \omega \in \Omega_p \\ \text{and } |H(\omega)| \leq \beta \text{ for } \omega \in \Omega_s \end{array} \right\}$$

where  $\mathbf{h}$  is the impulse response of length  $N$  of the SIRF filter that shortens the impulse response of a channel,  $\omega$  is a frequency,  $\alpha$  and  $\beta$  are error tolerance regions of frequency and time domain, respectively,  $H(\omega)$  is the impulse response in the frequency domain,  $R^N$  is the Hilbert space of dimension  $N$ ,  $\Omega_p$  is the pass-band and  $\Omega_s$  is the stop-band, as required by claims 7 and 25.

#### Claims 7 and 25: Second Rejection

Claims 7 and 25 are rejected under 35 U.S.C. §103(a) as being unpatentable over Haddad in view of Younce, and further in view of Khalil. Regarding claim 7, the Examiner asserts that Khalil discloses the additional limitations of claim 7 (page 716, col. 1, lines 20-40; col. 2).

Appellants could find no disclosure or suggestion by Khalil that a set of defining constraints that the **SIRF** filter must satisfy in the frequency domain is defined as follows:

$$C_2 \equiv \left\{ \begin{array}{l} \mathbf{h} \in R^N : 1 - \alpha \leq |H(\omega)| \leq 1 + \alpha \text{ for } \omega \in \Omega_p \\ \text{and } |H(\omega)| \leq \beta \text{ for } \omega \in \Omega_s \end{array} \right\}$$

where  $\mathbf{h}$  is the impulse response of length  $N$  of the SIRF filter that shortens the impulse response of a channel,  $\omega$  is a frequency,  $\alpha$  and  $\beta$  are error tolerance regions of frequency and time domain, respectively,  $H(\omega)$  is the impulse response in the frequency domain,  $R^N$  is the Hilbert space of dimension  $N$ ,  $\Omega_p$  is the pass-band and  $\Omega_s$  is the stop-band.

Thus, Nedic, Kapoor, Gandhi, Haddad, and Khalil, alone or in any combination, do not disclose or suggest wherein said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain is defined as follows:

$$C_2 \equiv \left\{ \begin{array}{l} \mathbf{h} \in R^N : 1 - \alpha \leq |H(\omega)| \leq 1 + \alpha \text{ for } \omega \in \Omega_p \\ \text{and } |H(\omega)| \leq \beta \text{ for } \omega \in \Omega_s \end{array} \right\}$$

where  $h$  is the impulse response of length  $N$  of the SIRF filter that shortens the impulse response of a channel,  $\omega$  is a frequency,  $\alpha$  and  $\beta$  are error tolerance regions of frequency and time domain, respectively,  $H(\omega)$  is the impulse response in the frequency domain,  $R^N$  is the Hilbert space of dimension  $N$ ,  $\Omega_p$  is the pass-band and  $\Omega_s$  is the stop-band, as required by claims 7 and 25.

5 Claims 8 and 26: First Rejection

Claims 8 was rejected under 35 U.S.C. §103(a) as being unpatentable over Nedic in view of Haddad, and further in view of Kahlil. Regarding claim 8, the Examiner asserts that Khalil discloses the additional limitations of claim 8 (page 716, col. 1, lines 20-40; col. 2).

Appellants could find no disclosure or suggestion by Khalil that a set of defining  
10 constraints that the **SIRF** filter must satisfy in the frequency domain is defined as follows:

$$C_3 \equiv \left\{ \begin{array}{l} \mathbf{h} \in R^N : 1 - \alpha \leq A(\omega) \leq 1 + \alpha \\ \text{and } \Phi(\omega) = -\omega(N-1)/2 \text{ for } \omega \in \Omega_p, \\ |H(\omega)| \leq \beta \text{ for } \omega \in \Omega_s, \end{array} \right\}.$$

where  $h$  is the impulse response of length  $N$  of the SIRF filter that shortens the impulse response of a channel,  $\omega$  is a frequency,  $\alpha$  and  $\beta$  are error tolerance regions of frequency and time domain, respectively,  $H(\omega)$  is the impulse response in the frequency domain,  $R^N$  is the Hilbert space of

15 dimension  $N$ ,  $\Omega_p$  is the pass-band,  $\Omega_s$  is the stop-band, 
$$A(\omega) = \sum_0^{N/2-1} 2h(n) \cos \left[ \left( n - \frac{N-1}{2} \right) \omega \right]$$

and  $\Phi(\omega) = -\frac{N-1}{2}\omega$ , wherein  $\Phi(\omega)$  and  $A(\omega)$  are independent filter characteristics and wherein  $\Phi(\omega)$  is a linear phase and  $A(\omega)$  is an amplitude.

Thus, Nedic, Kapoor, Gandhi, Haddad, and Khalil, alone or in any combination, do not disclose or suggest wherein said at least one set of defining constraints that said SIRF  
20 filter must satisfy in the frequency domain is defined as follows:

$$C_3 \equiv \left\{ \begin{array}{l} \mathbf{h} \in R^N : 1 - \alpha \leq A(\omega) \leq 1 + \alpha \\ \text{and } \Phi(\omega) = -\omega(N-1)/2 \text{ for } \omega \in \Omega_p, \\ |H(\omega)| \leq \beta \text{ for } \omega \in \Omega_s, \end{array} \right\}.$$

where  $h$  is the impulse response of length  $N$  of the SIRF filter that shortens the impulse response of a channel,  $\omega$  is a frequency,  $\alpha$  and  $\beta$  are error tolerance regions of frequency and time domain,

respectively,  $H(\omega)$  is the impulse response in the frequency domain,  $R^N$  is the Hilbert space of

dimension  $N$ ,  $\Omega_p$  is the pass-band,  $\Omega_s$  is the stop-band,

$$A(\omega) = \sum_0^{N/2-1} 2h(n) \cos \left[ \left( n - \frac{N-1}{2} \right) \omega \right]$$

and  $\Phi(\omega) = -\frac{N-1}{2} \omega$ , wherein  $\Phi(\omega)$  and  $A(\omega)$  are independent filter characteristics and wherein  $\Phi(\omega)$  is a linear phase and  $A(\omega)$  is an amplitude, as required by claims 8 and 26.

5 Claims 8 and 26: Second Rejection

Claims 8 was rejected under 35 U.S.C. §103(a) as being unpatentable over Haddad in view of Younce, and further in view of Khalil. Regarding claim 8, the Examiner asserts that Khalil discloses the additional limitations of claim 8 (page 716, col 1, lines 20-40; col 2).

10 Appellants could find no disclosure or suggestion by Khalil that a set of defining constraints that the **SIRF** filter must satisfy in the frequency domain is defined as follows:

$$C_3 \equiv \left\{ \begin{array}{l} \mathbf{h} \in R^N : 1 - \alpha \leq A(\omega) \leq 1 + \alpha \\ \text{and } \Phi(\omega) = -\omega(N-1)/2 \text{ for } \omega \in \Omega_p \\ |H(\omega)| \leq \beta \text{ for } \omega \in \Omega_s \end{array} \right\}$$

15 where  $\mathbf{h}$  is the impulse response of length  $N$  of the SIRF filter that shortens the impulse response of a channel,  $\omega$  is a frequency,  $\alpha$  and  $\beta$  are error tolerance regions of frequency and time domain, respectively,  $H(\omega)$  is the impulse response in the frequency domain,  $R^N$  is the Hilbert space of

dimension  $N$ ,  $\Omega_p$  is the pass-band,  $\Omega_s$  is the stop-band,

$$A(\omega) = \sum_0^{N/2-1} 2h(n) \cos \left[ \left( n - \frac{N-1}{2} \right) \omega \right]$$

and  $\Phi(\omega) = -\frac{N-1}{2} \omega$ , wherein  $\Phi(\omega)$  and  $A(\omega)$  are independent filter characteristics and wherein  $\Phi(\omega)$  is a linear phase and  $A(\omega)$  is an amplitude

20 Thus, Nedic, Kapoor, Gandhi, Haddad, and Khalil, alone or in any combination, do not disclose or suggest wherein said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain is defined as follows:

$$C_3 \equiv \left\{ \begin{array}{l} \mathbf{h} \in R^N : 1 - \alpha \leq A(\omega) \leq 1 + \alpha \\ \text{and } \Phi(\omega) = -\omega(N-1)/2 \text{ for } \omega \in \Omega_p, \\ |H(\omega)| \leq \beta \text{ for } \omega \in \Omega_s, \end{array} \right\}.$$

where  $\mathbf{h}$  is the impulse response of length  $N$  of the SIRF filter that shortens the impulse response of a channel,  $\omega$  is a frequency,  $\alpha$  and  $\beta$  are error tolerance regions of frequency and time domain, respectively,  $H(\omega)$  is the impulse response in the frequency domain,  $R^N$  is the Hilbert space of

5 dimension  $N$ ,  $\Omega_p$  is the pass-band,  $\Omega_s$  is the stop-band,  $A(\omega) = \sum_0^{N/2-1} 2h(n) \cos\left[\left(n - \frac{N-1}{2}\right)\omega\right]$

and  $\Phi(\omega) = -\frac{N-1}{2}\omega$ , wherein  $\Phi(\omega)$  and  $A(\omega)$  are independent filter characteristics and wherein  $\Phi(\omega)$  is a linear phase and  $A(\omega)$  is an amplitude, as required by claims 8 and 26.

#### Conclusion

10 The rejections of the independent claims under section 103 in view of Nedic, Younce, Gandhi, Khalil, and Haddad, alone or in combination, are therefore believed to be improper and should be withdrawn. The remaining rejected dependent claims are believed allowable for at least the reasons identified above with respect to the independent claims.

The attention of the Examiner and the Appeal Board to this matter is appreciated.

Respectfully submitted,

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APPENDIX

1 A method for determining coefficient values for a shortening impulse  
response filter (SIRF), said method comprising the steps of:

5 establishing at least one set of defining constraints that said SIRF filter must  
satisfy in a time domain;

establishing at least one set of defining constraints that said SIRF filter must  
satisfy in a frequency domain; and

determining an intersecting set of said at least one set of defining constraints that  
10 said SIRF filter must satisfy in the time domain and said at least one set of defining constraints  
that said SIRF filter must satisfy in the frequency domain by employing vector space projection  
methods.

2 The method according to claim 1, wherein said at least one set of defining  
15 constraints that said SIRF filter must satisfy in the time domain define a filter having a linear  
phase response.

3 The method according to claim 1, wherein said at least one set of defining  
constraints that said SIRF filter must satisfy in the frequency domain define a filter having a non-  
20 linear phase response

4 The method according to claim 1, wherein the time domain constraints specify  
a shortening of a channel impulse response.

25 5 The method according to claim 1, wherein the frequency domain constraints  
include a frequency response for said SIRF filter that does not attenuate a received signal

6 The method according to claim 1, wherein the frequency domain constraints  
include a pass-band for said SIRF filter.

7 The method according to claim 2, wherein said at least one set of defining constraints that the SIRF filter must satisfy in the frequency domain is defined as follows:

$$C_2 \equiv \left\{ \begin{array}{l} \mathbf{h} \in R^N : 1 - \alpha \leq |H(\omega)| \leq 1 + \alpha \text{ for } \omega \in \Omega_p \\ \text{and } |H(\omega)| \leq \beta \text{ for } \omega \in \Omega_s \end{array} \right\}.$$

5 where  $\mathbf{h}$  is the impulse response of length  $N$  of the SIRF filter that shortens the impulse response of a channel,  $\omega$  is a frequency,  $\alpha$  and  $\beta$  are error tolerance regions of frequency and time domain, respectively,  $H(\omega)$  is the impulse response in the frequency domain,  $R^N$  is the Hilbert space of dimension  $N$ ,  $\Omega_p$  is the pass-band and  $\Omega_s$  is the stop-band.

8 The method according to claim 3, wherein said at least one set of defining constraints that the SIRF filter must satisfy in the frequency domain is defined as follows:

$$C_3 \equiv \left\{ \begin{array}{l} \mathbf{h} \in R^N : 1 - \alpha \leq A(\omega) \leq 1 + \alpha \\ \text{and } \Phi(\omega) = -\omega(N-1)/2 \text{ for } \omega \in \Omega_p \\ |H(\omega)| \leq \beta \text{ for } \omega \in \Omega_s \end{array} \right\}.$$

where  $\mathbf{h}$  is the impulse response of length  $N$  of the SIRF filter that shortens the impulse response of a channel,  $\omega$  is a frequency,  $\alpha$  and  $\beta$  are error tolerance regions of frequency and time domain, respectively,  $H(\omega)$  is the impulse response in the frequency domain,  $R^N$  is the Hilbert space of

15 dimension  $N$ ,  $\Omega_p$  is the pass-band,  $\Omega_s$  is the stop-band,

and  $\Phi(\omega) = -\frac{N-1}{2}\omega$ , wherein  $\Phi(\omega)$  and  $A(\omega)$  are independent filter characteristics and wherein  $\Phi(\omega)$  is a linear phase and  $A(\omega)$  is an amplitude

9. (Cancelled)

20 10 The method according to claim 1, wherein said vector space projection method is iteratively applied to said at least one set of defining constraints that said SIRF filter must satisfy in the time domain and said at least one set of defining constraints that said SIRF



filter must satisfy in the frequency domain until the sets converge to a set of coefficients satisfying said time domain constraints and said frequency domain constraints.

11. A shortening impulse response filter (SIRF), comprising:

5 a set of finite impulse response (FIR) coefficients satisfying at least one constraint in a time domain and at least one constraint in a frequency domain, wherein said at least one time domain constraint is represented as at least one first set and wherein said at least one frequency domain constraint is represented as at least one second set, wherein said finite impulse response (FIR) coefficients are determined by an intersecting set of said at least one first set defining said  
10 time domain constraints and said at least one second set defining said frequency domain constraints, wherein said intersecting set is determined by employing vector space projection methods

12. The SIRF according to claim 11, wherein said at least one first set defining  
15 constraints that said SIRF filter must satisfy in a time domain define a filter having a linear phase response

13. The SIRF according to claim 11, wherein said at least one second set defining constraints that said SIRF filter must satisfy in a frequency domain define a filter having a non-  
20 linear phase response

14. The SIRF according to claim 11, wherein the time domain constraints specify a shortening of a channel impulse response.

25 15 The SIRF according to claim 11, wherein the frequency domain constraints include a frequency response for said SIRF filter that does not attenuate a received signal.

16. The SIRF according to claim 11, wherein the frequency domain constraints include a pass-band for said SIRF filter.

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17. (Cancelled)

18 The SIRF according to claim 11, wherein said vector space projection method is iteratively applied to said at least one first set defining said time domain constraints and said at least one second set defining said frequency domain constraints until the sets converge to a set of coefficients satisfying said time domain constraints and said frequency domain constraints.

19 A system for determining coefficient values for a shortening impulse response filter (SIRF), said system comprising:

a memory that stores computer-readable code; and  
a processor operatively coupled to said memory, said processor configured to implement said computer-readable code, said computer-readable code configured to:

establish at least one set of defining constraints that said SIRF filter must satisfy in a time domain;

establish at least one set of defining constraints that said SIRF filter must satisfy in a frequency domain; and

determine an intersecting set of said at least one set of defining constraints that said SIRF filter must satisfy in the time domain and said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain by employing vector space projection methods.

20 The system according to claim 19, wherein said at least one set of defining constraints that said SIRF filter must satisfy in the time domain define a filter having a linear phase response.

21 The system according to claim 19, wherein said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain define a filter having a non-linear phase response.

22 The system according to claim 19, wherein the time domain constraints specify a shortening of a channel impulse response.

23 The system according to claim 19, wherein the frequency domain constraints  
5 include a frequency response for said SIRF filter that does not attenuate a received signal

24. The system according to claim 19, wherein the frequency domain constraints include a pass-band for said SIRF filter.

10 25 The system according to claim 20, wherein said at least one set of defining constraints that the SIRF filter must satisfy in the frequency domain is defined as follows:

$$C_2 \equiv \left\{ \mathbf{h} \in R^N : 1 - \alpha \leq |H(\omega)| \leq 1 + \alpha \text{ for } \omega \in \Omega_p, \right. \\ \left. \text{and } |H(\omega)| \leq \beta \text{ for } \omega \in \Omega_s, \right\}.$$

where  $\mathbf{h}$  is the impulse response of length  $N$  of the SIRF filter that shortens the impulse response of a channel,  $\omega$  is a frequency,  $\alpha$  and  $\beta$  are error tolerance regions of frequency and time domain,  
15 respectively,  $H(\omega)$  is the impulse response in the frequency domain,  $R^N$  is the Hilbert space of dimension  $N$ ,  $\Omega_p$  is the pass-band and  $\Omega_s$  is the stop-band.

26 The system according to claim 21, wherein said at least one set of defining said domain constraints that the SIRF filter must satisfy in the frequency domain is defined as  
20 follows:

$$C_3 \equiv \left\{ \mathbf{h} \in R^N : 1 - \alpha \leq A(\omega) \leq 1 + \alpha \right. \\ \left. \text{and } \Phi(\omega) = -\omega(N-1)/2 \text{ for } \omega \in \Omega_p, \right. \\ \left. |H(\omega)| \leq \beta \text{ for } \omega \in \Omega_s, \right\}.$$

where  $\mathbf{h}$  is the impulse response of length  $N$  of the SIRF filter that shortens the impulse response of a channel,  $\omega$  is a frequency,  $\alpha$  and  $\beta$  are error tolerance regions of frequency and time domain, respectively,  $H(\omega)$  is the impulse response in the frequency domain,  $R^N$  is the Hilbert space of

dimension  $N$ ,  $\Omega_p$  is the pass-band,  $\Omega_s$  is the stop-band,  

$$A(\omega) = \sum_0^{N/2-1} 2h(n) \cos \left[ \left( n - \frac{N-1}{2} \right) \omega \right]$$
and  $\Phi(\omega) = -\frac{N-1}{2} \omega$ , wherein  $\Phi(\omega)$  and  $A(\omega)$  are independent filter characteristics and wherein  $\Phi(\omega)$  is a linear phase and  $A(\omega)$  is an amplitude.

5 27 (Cancelled)

28 The system according to claim 19, wherein said vector space projection  
method is iteratively applied to said at least one set of defining constraints that said SIRF filter  
10 must satisfy in the time domain and said at least one set of defining constraints that said SIRF  
filter must satisfy in the frequency domain until the set of defining constraints that said SIRF  
filter must satisfy in the time domain converge to a set of coefficients satisfying said time  
domain constraints and the set of defining constraints that said SIRF filter must satisfy in the  
frequency domain converge to a set of coefficients satisfying said frequency domain constraints

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EVIDENCE APPENDIX

There is no evidence submitted pursuant to § 1.130, 1.131, or 1.132 or entered by the Examiner and relied upon by appellant.

RELATED PROCEEDINGS APPENDIX

There are no known decisions rendered by a court or the Board in any proceeding identified pursuant to paragraph (c)(1)(ii) of 37 CFR 41.37.